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Site-Specific Assessment of Wood Residue Utilization Opportunities in the Libby, Montana area

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Executive Summary

# SITE-SPECIFIC ASSESSMENT OF WOOD RESIDUE UTILIZATION OPPORTUNITIES IN THE LIBBY, MONTANA AREA

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# INTRODUCTION

Although timber utilization practices have improved significantly in recent years, large volumes of wood residues remain unused. An increase in wood residue utilization depends upon such factors as availability, accessibility, outlook for continued supply, and cost of recovery.

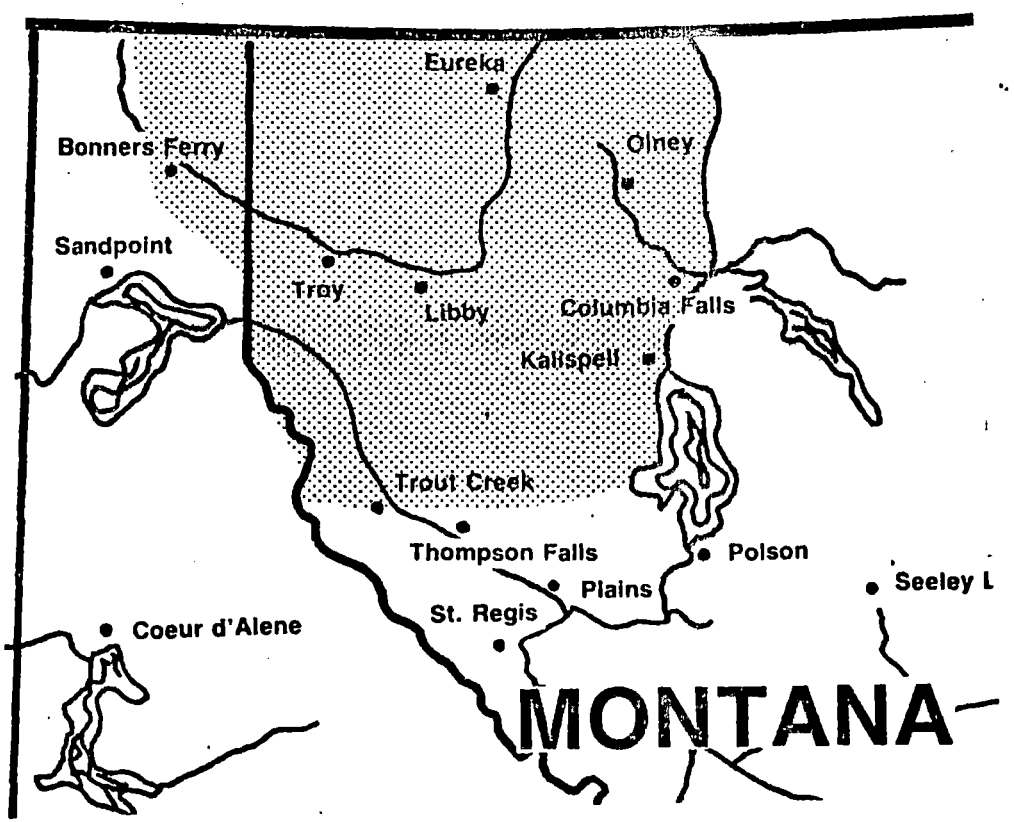
A recent General Accounting Office report identified one of the barriers to improved utilization as insufficient assessment of residue utilization opportunities on a localized, site-specific bases. More comprehensive information for specific areas is considered essential for industrial planning and capital investment, for predicting future wood supply, and conducting economic feasibility analysis.

To attempt to provide this comprehensive information essential to improved residue utilization, a cooperative project was undertaken involving the Intermountain Forest and Range Experiment Station of the U.S. Forest Service and the Bureau of Business and Economic Research at the University of Montana. The project was funded by the U.S. Department of Energy.

The study area chosen for this project was the area comprising the timber supply zone for primary wood products manufacturers in Libby, Montana (figure 1). The area surrounding Libby, Montana was chosen for the following reasons:

1. It is centrally located in one of the largest timber-producing regions in the Inland Northwest.
2. It is a major wood products producing center.
3. Harvest levels and species composition indicate large volumes of forest residue are available in the area.

**Figure 1**
**Libby, Montana Supply Zone**



4. There has been considerable local interest in residue utilization for power generation.
5. Most of the timber harvest activity occurs on National Forest lands or industrial forest lands, making resource data readily available.

## GOALS AND OBJECTIVES

Goal 1. The principal goal of this project was to provide the detailed information necessary to assess the feasibility of increased wood fiber residue utilization. The emphasis was on the use of wood residue for electrical generation in northwestern Montana.

Goal 2. An additional goal of the project was to develop methodology which could be applied in other geographic areas to analyze residue availability.

Objectives. The objectives of the study were to:

1. Develop detailed estimates of present and future wood residue volumes, locations, characteristics and availabilities in the Libby area.
2. Estimate the costs of recovering residue of various types.
3. Identify the potential for and needs ~~of~~ for improved technology for residue recovery.
4. Evaluate the financial feasibility of supplying a power generating facility with wood fiber residue.
5. Identify additional barriers to residue utilization and/or benefits from increased residue utilization.

This summary provides the highlights of the study and focuses on estimates of residue availability and cost and the financial analysis of wood energy facilities.

## WOOD RESIDUE AVAILABILITY AND COST

Wood fiber residue in the Libby area has two major components: mill residue and forest residue. Mill residue is wood fiber residue generated from processing logs into lumber, plywood and other wood products. Forest residue is that component of the available timber resource not currently being utilized. It includes slash from logging operations and road right-of-way projects, as well as dead and cull green material on sites not scheduled for logging, and small stems from timber stand improvement projects.

Unutilized mill residue generally is a much cheaper source of wood fiber than forest residue. However, much of the mill residue generated annually in the region is committed. Therefore, a new power generating facility in the area may have to compete directly with existing users for this source of wood fiber (Keegan and White 1979). Because mill residue is inexpensive when available, it will be discussed in detail.

The most promising source of uncommitted forest residue available to supply a large volume user is produced during conventional sawtimber harvesting operations. This component, referred to as logging residue, is the cheapest and most accessible type of forest residue resource and was focused on specifically in this project. Other components of forest residue were assessed in less detail.

## Mill Residue Availability and Cost

All plants processing timber into primary wood products generate mill residue. However, over 95 percent of the mill residue generated in the Inland Empire comes from sawmills and plywood plants. This analysis deals with mill residue from only these operations.

The three types of mill residue generated at sawmills and plywood plants are: 1) coarse or chippable residue consisting of slabs, edgings, and trim from lumber manufacturing, log ends from sawmills and plywood plants, pieces of veneer not suitable for plywood manufacture, and peeler cores from plywood plants not sawn into lumber; 2) fine residue consisting of planer shavings and sawdust from sawmills and sander dust from plywood plants; and 3) bark, from sawmills and plywood plants.

Coarse residue is utilized primarily as a raw material by the pulp and paper industry. Fine residue is used as a raw material for the pulp and board industry and for fuel, while bark residue is used almost exclusively for fuel. There is a large demand for coarse residue within the Inland Empire. Accompanying the high demand for coarse residue is its higher price, $30-$80 per cunit FOB producer's mill, versus under $10 for fine residue and bark (Keegan et al. 1982, 1984).

A new user, such as a power generating facility using fine residue and bark, would certainly try not to compete for coarse residue and concentrate on the lower cost residue components.

Demand Versus Supply. The Inland Empire's estimated annual supply of mill residue should exceed regional demand in a normal year by nearly 460 thousand cunits (table 1).[1] Sawmills and plywood plants will generate

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[1]The Inland Empire refers to northeastern Washington, north Idaho, and western Montana.

Table 1

Estimated Annual Demand for, and Supply of Mill Residue, Inland Empire "Normal Year" (Thousand Cunits)

| | Coarse Residue[a] | Fine Residue[b] | Bark | Total |
|---|---|---|---|---|
| Supply from sawmills and plywood plants | 1,880 | 1,285 | 790 | 3,955 |
| Less: Expected demand for raw materials from pulp and board plants | 1,610 | 595 | --- | 2,205 |
| Residue available for use as hogfuel | ----- | 690 | 790 | 1,480 |
| Less: Expected demand for hogfuel | ----- | --- 1,290 | --- | 1,290 |
| Projected residue excess from sawmills and plywood plants | 270 | --- 190 | --- | 460 |

Sources: Bureau of Business and Economic Research (1977, 1981, 1982), Cody (1980), Forest Products Journal (1982), Larsen and Gee (1981), and U.S. Department of Energy (1982).

Notes: The Inland Empire refers to northeastern Washington, north Idaho, and the major timber producing regions of Montana. A normal year for the industry is one in which there are between 1.5 and 1.6 million housing starts nationwide. Demand represents the volume of wood fiber the plant would require to operate at capacity. For the pulp and paper industry, reconstituted board plants, and energy facilities stated capacity was assumed to be their normal operating level.

[a] Material suitable for chipping such as slabs, edgings, and trimmings.
[b] Material such as sawdust and planer shavings.

an estimated 3.95 million cunits in a normal year. Estimated requirements from users within the region are 3.49 million cunits.

Virtually all of the excess coarse residue, 270 thousand cunits, is utilized by manufacturers out of the region (Keegan and Jackson 1984). Projected supplies of fine residue and bark should exceed demand by 190 thousand cunits for a year of normal lumber and plywood production. Because bark and fine residue can be substituted for fuel, individual estimates of excess volumes were not made in the Inland Empire region.

Most of the unused fine residue and bark is in counties adjacent to Lincoln County, Montana, in north Idaho, or other counties in northwestern Montana. Users in northwestern Montana could contract annually for volumes of unutilized fine mill residue and bark of slightly more than 100 thousand cunits, given lumber production levels at or above normal levels. This material, delivered to a user in Lincoln County, would certainly cost less than recovering forest residue.

Delivered costs for fine residue and bark should range between $10 and $30 per cunit. Cost to a mill utilizing its own excess residue would be lower, approximately $5 per cunit. As will be discussed later, competition could make the price of bark and fine mill residue considerably higher in the future. If a user required the entire 100 thousand plus cunits annually, it would probably be necessary to either sharply curtail operations during periods of lower than normal lumber production or rely heavily on forest residue.

## Forest Residue Availability and Cost

Timberlands in the northern Rocky Mountains hold large quantities of wood fiber which are neither sawtimber nor desirable growing stock. Much of it is not utilized and would fall into the general category of forest residue. For purposes of this report, forest residue is defined as:

1. Logging residue which consists of large dead and cull green material including crowns and unmerchantable bole tips currently left on logging sites, and cull portions of the boles of sawtimber trees.
2. Material cut and left on site in timber stand improvement practices such as thinnings or stand conversion operations.
3. Material remaining from past years' logging operations.
4. Dead, small and cull green material on sites not scheduled for commercial harvesting operations or timber stand improvement.

The potential of these sources to supply major users of wood fiber in the Libby, Montana area was examined. (See figure 1 for the boundaries of the supply zone.) Specifically, the objectives were to estimate: 1) the volumes of the various components of forest residue available annually for the period 1986 to 1995, within a 100-mile haul of Libby, Montana, and 2) the cost of recovering that material. One type of forest residue -- logging residue -- received major emphasis.

General Methodology. Forest residue volume estimates are based on residue volume factors applied to harvest levels or land area available for treatment (Keegan, Jackson and Chase 1984). Cost estimates are based

on a model developed at the Bureau of Business and Economic Research to estimate the cost of recovering forest residue in the northern Rocky Mountains (Jackson et al. 1984).

The supply schedule presented below represents estimates of the most economically attractive supply situation a large volume user of forest residue for energy would face in the Libby area annually for the next ten years (table 2). A large volume user refers to an operation with raw material needs exceeding 20 thousand cunits per year. A supply schedule applicable to small volume nontypical recovery systems was not developed. The cost and available volumes presented are based on high volume, production oriented, conventional harvesting systems.

Logging Residue: The First Choice: The forest residue supply schedule for the Libby, Montana area is shown in table 2. It is categorized by logging residue and other components of forest residue. Only logging residue appears potentially able to supply large volumes of additional wood fiber in the Libby, Montana area at a reasonable cost.

Probably the best logging residue components suitable for fuel in an energy facility ~~is~~ are the tops and crowns of sawtimber trees and cull portions of boles of sawtimber trees recovered in whole tree logging operations. An estimated 120-200 thousand cunits would be available annually through whole tree logging in the Libby, Montana area for an estimated cost of $25 to $65 per cunit (delivered and chipped), with an estimated average cost of $45 per cunit in 1984 dollars.

Crowns and unmerchantable bole tips of sawtimber trees are especially advantageous to energy users. First of all, they are potentially cheaper than the other components of forest residue. Second, there would be little competition from product producers such as pulp and paper or

Table 2

Forest Residue Supply Schedule Available
Annually to an Energy Facility
Libby, Montana
1986-1995

| Source | (000 Cunits) | Estimated Cost (1984 Dollars) |
|---|---|---|
| Logging Residue | | |
| Volume through whole tree recovery[1] | 120-200 | $25-$65/cunit<br>Average $45/cunit |
| Cull logs and trees from tractor sites | 41 | $65/cunit |
| Cull logs and trees from cable sites | 17 | Over $80/cunit |
| Other Forest Residue Components | | |
| Stand conversion residue | | |
| Slopes to 20 percent | Under 10 | Over $65/cunit |
| Slopes 20-40 percent | Under 20 | Over $80/cunit |
| Backlog slash | Minimal | Over $80/cunit |
| Selection or salvage logging cull material | Large Volumes | Over $80/cunit |

Source: University of Montana, Bureau of Business and Economic Research, Libby, Montana Logging Residue Inventory (Missoula, Montana, 1984).

[1]The lower volume estimate in this schedule represents wood fiber available by in-woods processing of whole sawtimber trees. The upper volume figure represents estimated volumes available if mill site processing is undertaken. The costs of wood fiber available through the two approaches did not differ greatly. Also included in the estimate are 38 thousand cunits representing cull portions of the boles of sawtimber trees currently bucked-out and left on logging sites.

waferboard because these users generally require wood fiber pieces large enough to flake or chip and have a low tolerance for bark.

However, the availability and cost of crowns and unmerchantable bole tips is uncertain. Much of the recovery data used in this analysis are from case studies done in other regions in North America. Nevertheless, it is the only source of forest residue in the Libby area that would have the potential to supply a relatively large user at a relatively low cost.

Additional Units of Logging Residue. As the material recoverable in whole tree operations is exhausted, the next most promising type of forest residue should be cull logs recovered during sawtimber harvest operations on tractor ground. The volumes of this material in the area appear limited, with only about 41 thousand cunits of additional material available from all tractor ground in the supply zone at an estimated cost of $65 per cunit.[2]

Other Components of Forest Residue: Components of forest residue other than logging residue cost much more than most logging residue. The next least expensive source of forest residue appears to be residual material from the conversion of stagnant lodgepole pine stands in the area. This material, however, is unable to supply large volume users. The estimated 10 thousand cunits available annually from slopes under 20 percent have an estimated cost of more than $65 per cunit and the 20 thousand cunits on slopes from 20 to 40 percent have an estimated delivered and chipped cost of more than $80 per cunit.

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[2]These estimates include only logging residue in pieces larger than 4 cubic feet in size. Much greater volumes of smaller pieces would be available but at much higher prices.

Large volumes of wood fiber from backlog slash and selectively logged material would be available but estimated costs would be over $80 per cunit.

The Mountain Pine Beetle Epidemic. An infestation of mountain pine beetle in the supply area has reached epidemic proportions. It is anticipated that all lodgepole pine (LPP) stands over eighty years old and 6 inches in diameter on the Kootenai National Forest will be infected by the mountain pine beetle in the next ten years (U.S.D.A. 1982). This represents a volume of just under 3 billion board feet.

The Kootenai National Forest has undertaken a large salvage program aimed at recovering the impacted LPP for lumber production. Because of constraints imposed by the ability of the wood products industry in the area to absorb LPP and constraints imposed by accessability and other resources, harvest levels will be much lower than anticipated losses.

Given present recovery rates, only about one-third of the 3 billion board feet of dead LPP will have been recovered by 1995. Since at that time much of the LPP will have been dead for more than ten years, its potential for lumber recovery will be greatly reduced. Beetle killed LPP could then become a major source of wood fiber for fuel in the period after 1995.

## COMPETITION FOR WOOD FOR ENERGY

Most of the material that fits into the category of wood fiber residue is usable, but is underutilized because of high recovery costs, inaccessibility, and low value. Much of the residue material could have multiple uses. For example, although sound dead lodgepole

pine (12 inches d.b.h.) might be considered a residue in many parts of the northern Rocky Mountains, this material could produce lumber and other sawn products, veneer logs, house logs, utility poles, pulp and reconstituted board products, as well as home and industrial fuel.

In this section, the value of wood fiber for various competing industrial users in the Inland Empire will be examined. It summarizes an analysis reported in "The Value of Wood to Competing Users: Value Use" (Keegan and Jackson 1984). This value indicates the user's willingness to pay for delivered wood over the long term and is referred to as value use.

Estimating Value Use

Wood is only one of the materials necessary to produce outputs of energy or wood products. The long-run value of wood varies for each user depending on the value of the product produced and the rate of return required, as well as on other production costs and the availability of wood versus potential substitutes.

Because of the variability in value of wood to a specific plant, ranges were developed to reflect what energy users and potential competitors could pay over the long term for wood fiber. The estimates are not precise figures of the value of wood to various users, but only an indication of whether or not plants or facilities might be expected to purchase wood in competition with other users in the Inland Northwest.

The assumption was made that wood fiber in quality up to and including material suitable for stud logs and house logs might be used competitively by fuel or fiber facilities. The potential uses

examined for value ranges were electrical generation, industrial fuel, and the manufacture of pulp, reconstituted boards, posts, poles, rails, studs, and house logs.

Value use ranges were estimated based on the following:

1. A survey of existing plants where operators were asked what they could pay for wood fiber delivered to the facility and still operate profitably (Keegan et al. 1981).
2. Historical prices paid or received for various types of wood fiber (Bureau of Business and Economic Research 1977, 1982, 1983 and Hawkins 1984).
3. Published estimates of capital costs, projected revenues and other operating costs, and/or from published estimates of value use (Anonymous 1984, Carroll, Hatch and Associates 1983, EBASCO Services Inc. 1982, Fahey 1980, Flodin 1983, General Electric Company 1982, Jackson, Keegan and Withycombe 1984, Levi and O'Grady 1980, Pennington 1984, Schuchart and Associates 1980, U.S. Department of Agriculture 1978, and Withycombe 1974).

Comparative Values of Wood

Table 3 indicates the estimated mill delivered value use range of a cunit of wood fiber in the Inland Empire. As can be seen, the uses of wood to manufacture a product generally have a higher value use range than the energy uses. A number of energy uses for wood, however, have value use ranges that overlap those of the product uses.

The uses of wood as a substitute for coal or to generate electricity have value ranges well below those for most manufacturing uses. The

Table 3

Estimated Value Use of Wood Fiber
Energy and Selected Products
Inland Empire Region
(1984 Dollars)

| Use | Mill Delivered Value per Cunit |
|---|---|
| Electrical Generation | $ 0-$ 25 |
| Industrial Fuel to Replace | |
| Coal | $ 25-$ 35 |
| Natural Gas | $ 0-$ 65 |
| Fuel Oil | $ 0-$ 70 |
| Raw Material to Produce | |
| Reconstituted Boards | |
| Particleboard | $ 15-$ 40 |
| Fiberboard | $ 30-$ 80 |
| Waferboard | $ 50-$100 |
| Pulp and Paper | $ 50-$100 |
| Solid Products | |
| Post, Rails, Poles | $ 50-$ 80 |
| Studs | $ 60-$ 90 |
| House Logs | $100+ |

exceptions would be low-value manufacturing uses such as particleboard production.

It appears, however, that wood could substitute for fuel oil and natural gas in industrial boilers, and be competitive with a number of product uses. Again, the value use range for wood in place of fuel oil or natural gas is large, due primarily to variability in capital costs of wood boiler systems. Given relatively low capital costs for wood systems, using wood as a fuel appears competitive with many product uses.

Much of the variation in value use for products relates to market conditions. Wood as a substitute for natural gas or fuel oil would compete with the particleboard and fiberboard industries under both good and bad wood products market conditions. During periods of high demand for pulpwood or solid wood products, energy users of wood might have a difficult time competing.

The Inland Empire has seen virtually no large-scale competition between industrial fuelwood users and manufacturers using wood as a raw material or among fuel users or manufacturers. This situation could easily change in the future.

Lack of Competition in the Past. Competition between wood energy users and manufacturers has been limited, primarily because industrial fuelwood users used material that was either not suitable for product uses or was available in quantities much greater than that needed.

Almost all of the industrial fuelwood needs in the Inland Empire have been met by utilizing the wood fiber residue from the manufacture of lumber and plywood (mill residue). The mill residue components

generally used for fuel are bark and fine residue (composed of planer shavings and sawdust). No major manufacturers in the region currently utilize bark as a raw material to produce a product. Planer shavings and sawdust are used as a raw material by particleboard and fiberboard plants and sawdust by pulp and paper mills. However, during years of average and above-average lumber production, supplies of these have exceeded fuel and raw material needs (Keegan and Jackson 1984). Because of this surplus, there has been little direct competition between energy users and product users. Low prices for bark and fine residue (currently priced at under $10 per cunit FOB the producer's mill and averaging under $25 per cunit delivered to the user) reflect this lack of competition.

Wood Costs to New Energy Users

As indicated above, excess mill residue still exists in the region, at least in years of average or above lumber production. A new user, especially in northwestern Montana and north Idaho, might still be able to secure moderate volumes (100 thousand cunits of fine residue and bark) for prices well below those indicated by the value uses in table 3. This situtation, however, may exist only in the near term.

The projected excess supply of mill residue for years of average lumber production is small in relation to total supply and demand (Keegan and Jackson 1984). Therefore, even modest increases in average annual demand for residue (or small decreases in the size of the lumber and plywood industry) would over the long term lead to greater direct competition among users of wood fiber residue and much higher prices for bark and fine residue available at sawmills and plywood plants.

A prospective user of mill residue must be aware that lumber production varies considerably from year to year, due to volatile lumber markets. Five of the ten years between 1974 and 1983 were years of below-average lumber and plywood production. Given current demand for mill residue, short-falls of supply would occur if lumber production dropped to the levels experienced in any of those five years (Keegan and Jackson 1984).

The coming decade should not include a recession in wood products as severe as during 1980-1982. No shortages are projected for five of the next ten years, but users should remember that downturns in the lumber markets can occur at any time. Users may be forced in lean years to pay much more for wood fiber, either because competition for mill residue has driven prices up or because they are forced to recover forest residue.

Both in the near and distant future, new large-volume users of wood for energy should be prepared to pay more for wood than was ~~paid~~ in the past paid out for fine mill residue and bark -- unless they have firm long-term contracts for mill residue.

## THE FINANCIAL FEASIBILITY OF USING WOOD FOR ELECTRICAL GENERATION

The primary focus of the financial analysis was on the use of wood fiber residue to generate electricity. This section summarizes an analysis reported in "A Financial Analysis of Generating Electricity from Wood Fuel in Northwestern Montana" (Jackson et al. 1984). A range of types and sizes of wood-fired systems were analyzed in detail to determine the feasibility of producing electricity using wood residue for fuel.

Four specific facilities were evaluated. These case studies involved two cogeneration facilities and two stand-alone wood-fired plants. Cogeneration is the generation of process steam, process heat, or space conditioning combined with the generation of electrical power. A stand-alone plant produces electrical power only.

The two cogeneration systems evaluated were a 5-megawatt system and a 15-megawatt system. These represent a range of sizes compatible with the industry in northwestern Montana and the Inland Empire region. A 5-megawatt system could be sustained using the low value mill residue (bark, planer shavings and sawdust) generated by a sawmill producing 40 to 60 MMBF of lumber annually.[3] This would be considered a medium to large-sized mill in the region.

The 15-megawatt facility could be supplied by the bark and fine residue generated by a large mill complex processing in excess of 100 MMBF, Scribner of timber, approximately 70 percent into lumber and 30 percent into plywood.

Two stand-alone facilities ~~will be~~ were also examined -- a 15 and a 25-megawatt facility.

Capital, Operating, and Maintenance Cost Estimates

Capital costs for both cogeneration and stand-alone wood-fired generating plants were obtained from a computer program written by

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[3]The coarse residue could also be used to fuel a power facility. Presently, coarse residue is virtually all used by the pulp and paper industry in the region and has a value FOB producing mill in excess of $40 per cunit versus approximately $5 per cunit for bark, planer shavings and sawdust.

General Electric Company under contract to the Electric Power Research Institute.[4] The data base includes both capital costs and operation and maintenance costs for a wide range of sizes and types of cogeneration plants. The costs are based on feasibility studies done by General Electric and others, and have been carefully validated. They are expressed in 1984 dollars. The installed capital costs for several combinations of mill and generator sizes are shown in table 4.

The proportion of cost of a cogeneration system that must be allocated to the generation of electricity is generally lower than that shown in table 4. If, for example, a facility such as a sawmill needs a new process steam facility, then the cost of a process steam system alone should be deducted from the total cost of the cogeneration system to determine capital costs applicable to electrical generation. This assumption (that a process steam system was needed) was made in determining the base capital cost to be used in the four cases evaluated in this analysis.

To examine the sensitivity of the financial analysis to changing levels of capital costs, the base capital costs for the four case studies were increased and decreased by 25 percent. A number of sources indicate that the capital costs can be significantly reduced if refurbished equipment (i.e. boilers, turbine generators) is substituted for new equipment. These sources indicate the capital cost of the project can be reduced from $1.8 to $2.6 million per

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[4]The computer program and data base is available (on a fee basis) to interested users from the Electric Power Research Institute in Palo Alto, California.

Table 4

Capital Costs of Wood-fired Generators
Installed Cost (In Millions of 1984 Dollars)

| Mill Size | Generator Size | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 MW | 5 MW | 7 MW | 10 MW | 15 MW | 20 MW | 25 MW | 50 MW |
| Stand-alone | - | - | - | $ 25.0 | 32.1 | 38.0 | 44.2 | 68.0 |
| 20-40 MMBF Mill (11,000 lb/hr steam) | $ 8.8 | 14.6 | 20.5 | 25.4 | - | - | - | - |
| 40-60 MMBF Mill (19,000 lb/hr steam) | 9.0 | 15.0 | 21.0 | 25.8 | - | - | - | - |
| 70-100 MMBF Mill (26,000 lb/hr steam) | - | 15.3 | 21.4 | 26.2 | 33.2 | - | - | - |
| Mill Complex 125 MMBF Lumber 100 MMSF Plywood (78,000 lb/hr steam) | - | - | - | 28.9 | 35.6 | 41.6 | - | - |

Sources: General Electric Company for the Electric Power Research Institute, DEUS Computer Evaluation Model (Palo Alto, California, 1982) and Bureau of Business and Economic Research, University of Montana (Missoula, Montana, 1984).

megawatt to approximately $1 million per megawatt. A separate analysis was also done using a capital cost of $1 million per megawatt.

For all plants, the operating and maintenance costs were assumed at between 5 and 7 percent of the installed base capital costs. These costs include materials and labor to operate the plant, but not fuel.

Fuel Costs

Three levels of wood fiber costs were used in the financial analysis, $5, $20 and $50 per cunit. The $5 per cunit cost was used to illustrate a plant utilizing mill residue generated on site and attaching an opportunity cost about equal to current prices for fine mill residue and bark.

The $20 per cunit cost represents two situations. First, a case in which excess mill residue was purchased from sawmills and/or plywood plants at current prices of $5 per cunit with a $15 per cunit allowance for shipping and handling. Second, the $20 per cunit cost illustrates the opportunity cost, to mills, of utilizing their own mill residue for electrical generation given increases in prices to $20 per cunit.

The $50 per cunit cost was used to evaluate the financial feasibility of using forest residue to generate electricity.

Revenues from Electrical Generation

As outlined in the Public Utility Regulatory Policy Act (PURPA) and the Montana State "mini-PURPA" (Administrative Rules of Montana 38.5. 1901-1903), each public utility is obligated to purchase any energy and capacity made available by a qualifying facility. It was assumed that a qualifying facility in northwestern Montana would sell electrical power to Pacific Power and Light Compnay (PP&L) of Portland, Oregon.

The Public Service Commission ruled that three long-term payment options be fixed by law with PP&L. The three options include a completely levelized rate option, an escalating-partially levelized rate option, and an unlevelized rate option.

For this analysis the current "fully levelized" rate was used. The base case will assume a buyback rate of 6.27¢ per kilowatt hour. The sensitivity of the four options to electrical buyback rates of up to 9.5¢ per kilowatt hour will also be analyzed.

The two other rate options were also evaluated. The initial rates are substantially lower for the "escalating rate" and "partially levelized" rate. The "fully levelized" option is the most attractive, unless very large increases in variable buyback rates are assumed.

## The Financial Model

The traditional approach to capital budgeting as described by Brigham (1979) is the financial model used in this analysis. The method does not explicitly bring the project's financing into the cash flow analysis. As a result, taxable income is overstated, hence taxes are also overstated and the net cash flows from the project are understated.

However, the cost of capital used to determine the project's Net Present Value (NPV) is adjusted for taxes, and this adjustment largely offsets the understatement of cash flows.

The traditional model employed is outlined below:

TRADITIONAL FINANCIAL MODEL

Earnings Before Interest and Taxes
Minus: Tax Bill
Net Income
Plus Depreciation
Net Cash Flow Available to All Investors

The net cash flows from the traditional model are the cash flows available to all investors.

Financial Feasibility of Electrical Generation

Table 5 provides a summary of inputs to the model. Again, all costs and variables associated with the two cogeneration alternatives (options 1 & 2) are the incremental costs associated with the production of power. It is assumed that the facility (sawmill, plywood plant, etc.) needs a new process steam system. Therefore, the costs associated with the process steam system are deducted from the total cost of the cogeneration project.

Both net present value and internal rate of return were calculated for the four case studies. This was done for the various levels of capital costs, fuel costs, and revenue rates for electricity. In figures 2 through 5 the net present value is indicated on the y axis for various after-tax discount rates indicated on the x axis. The internal rate of return is the discount rate at which the net present value is equal to zero. The benchmark discount rate chosen was 14.6 percent. This is the return on equity for the 500 largest manufacturing firms in the United States from 1973 to 1983.[5]

Given a discount rate of 14.6 percent, none of the base capital cost cases (capital costs of $1.8 to $2.6 million per megawatt hour) would be attractive investments at current fully levelized electrical buyback rates (6.27¢ per kilowatt hour) even with wood fuel costs of $5 per cunit.

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[5]Developed from *Fortune Magazine*, April 30, 1984, pg. 296, Total Return to Investors, 1973-1983 from the Fortune 500 All Industries Average.

Table 5

Summary of Values and Assumptions for the
Four Base Case Power Plant Options

| | Option 1 | Option 2 | Option 3 | Option 4 |
|---|---|---|---|---|
| Project Type | Cogeneration | Cogeneration | Stand-alone | Stand-alone |
| Project Life | 20 yrs | 20 yrs | 20 yrs | 20 yrs |
| Electrical Capacity (MW) | 5.0 | 15.0 | 15.0 | 25.0 |
| Electrical Generation (Million KWH) | 40.3 | 120.9 | 120.9 | 201.6 |
| Capital Cost (In Millions of 1984 Dollars) | $ 13.3 | $ 30.6 | $ 32.1 | $ 44.2 |
| Investment Tax Credit (Percent) | 10% | 10% | 10% | 10% |
| Depreciation Method[a] | ---------- ACCELERATED COST RECOVERY SYSTEM ---------- | | | |
| First Year Operating & Maintenance Costs (In Millions of 1984 Dollars) | $ 0.8 | $ 1.6 | $ 1.7 | $ 2.2 |
| Fuel Consumption (Cunits) | 24,170 | 68,030 | 84,620 | 141,040 |
| Growth Rate of Operating & Maintenance Costs and Fuel Costs | 5% | 5% | 5% | 5% |
| PURPA Buyback Option | ---------- FULLY LEVELIZED FIXED RATE ---------- | | | |
| Tax Rate | 46% | 46% | 46% | 46% |

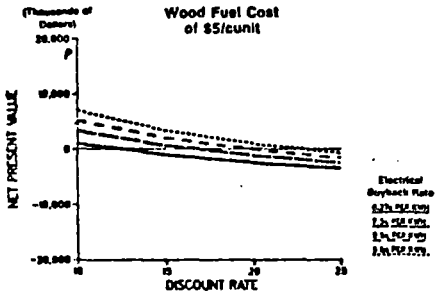
Sources: General Electric Company for the Electric Power Research Institute (Palo Alto, California, 1982) and Bureau of Business and Economic Research, University of Montana (Missoula, Montana, 1984).

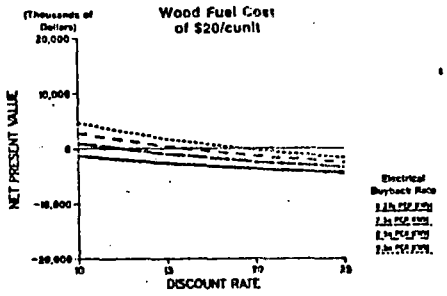
Notes: All costs and variables associated with the cogeneration facilities (Options 1 & 2) are the incremental costs associated with the production of power. In essence, we have assumed that a facility (sawmill, etc.) is in need of a new process steam system, therefore, all additional costs over and above the process steam facility are attributable to power production.

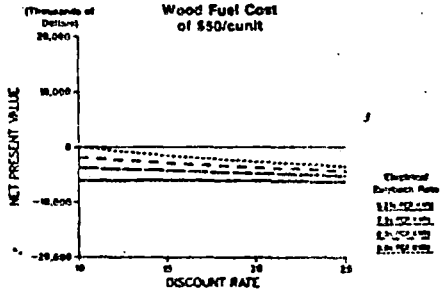
[a]See table 6 for the applicable depreciation categories.

# Figure 2
## Five Megawatt Cogeneration Facility (Option 1)
## Net Present Value at Various Discount Rates

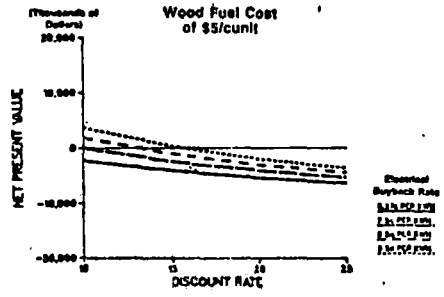
**Low Capital Cost $9.97 Million (1984 Dollars)**

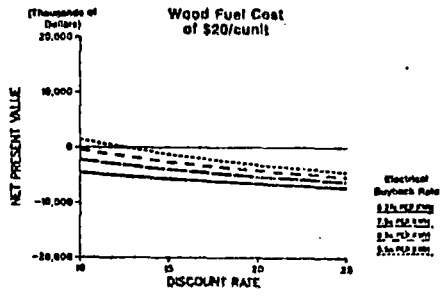


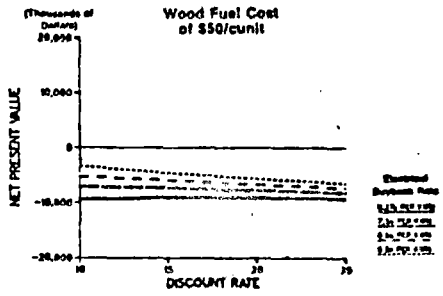



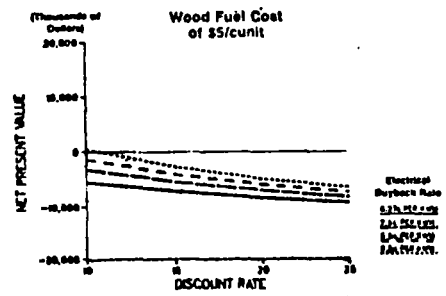

**Base Capital Cost $13.3 Million (1984 Dollars)**

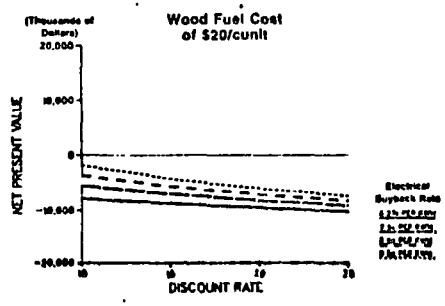


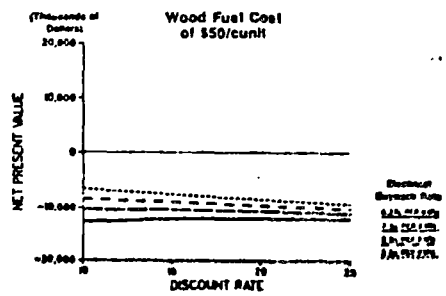




**High Capital Cost $16.6 Million (1984 Dollars)**

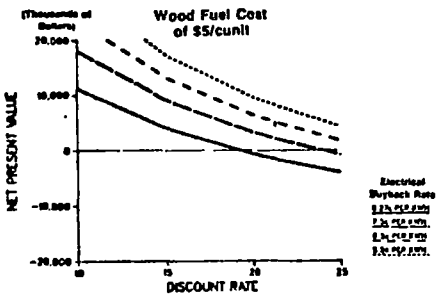


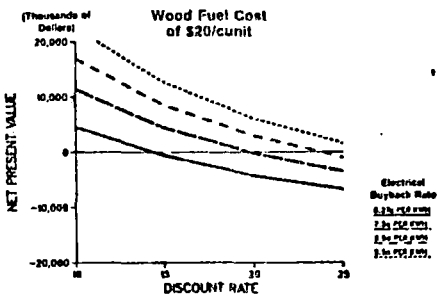



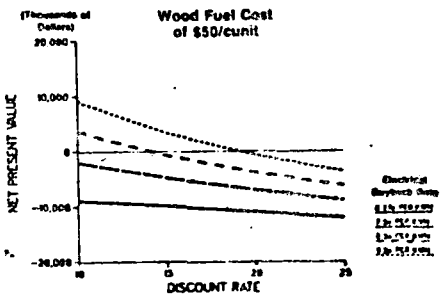



# Figure 3
## Fifteen Megawatt Cogeneration Facility (Option 2)
## Net Present Value at Various Discount Rates

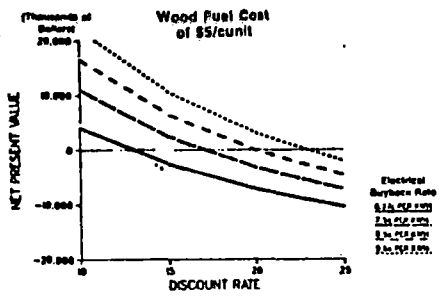
**Low Capital Cost $22.9 Million (1984 Dollars)**

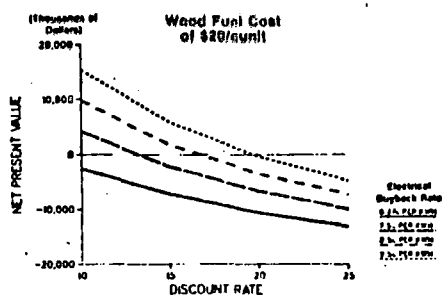


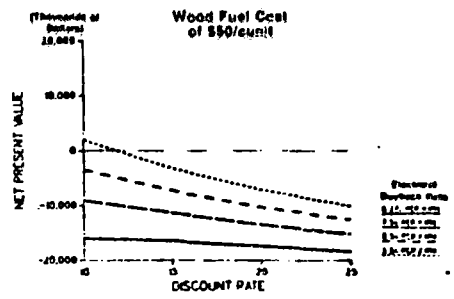



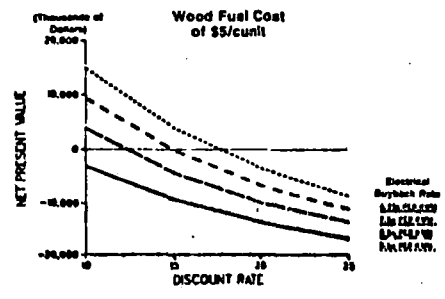

**Base Capital Cost $30.6 Million (1984 Dollars)**

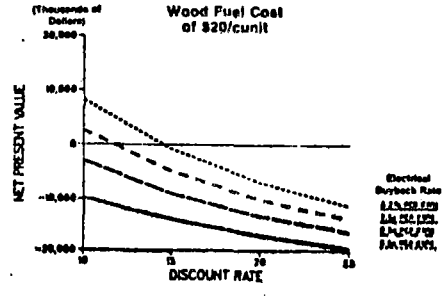


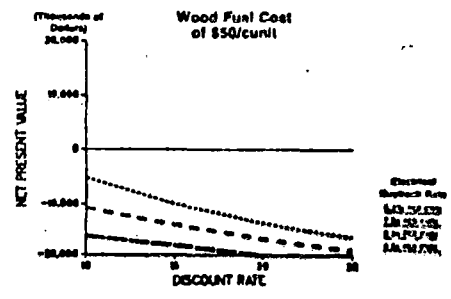




**High Capital Cost $38.2 Million (1984 Dollars)**

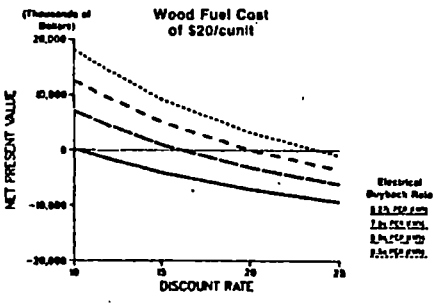


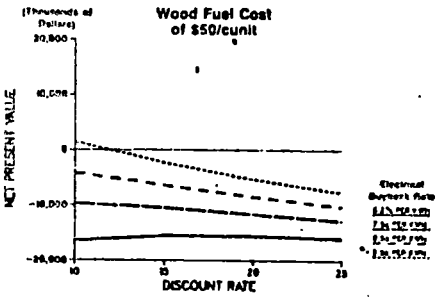



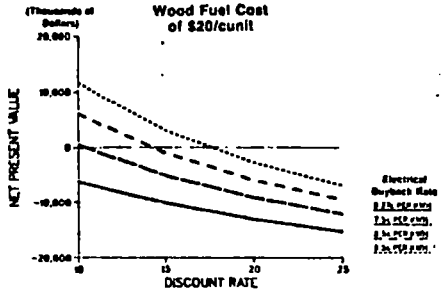
# Figure 4
# Fifteen Megawatt Stand Alone Facility (Option 3)
# Net Present Value at Various Discount Rates

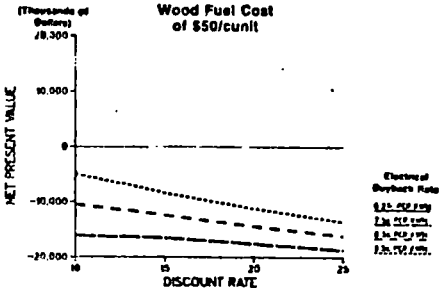
**Low Capital Cost $24.1 Million (1984 Dollars)**



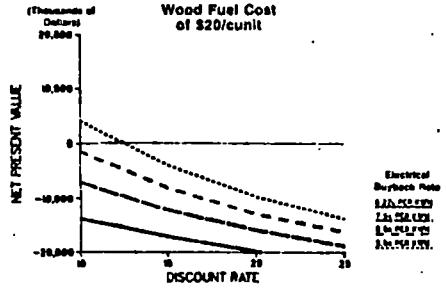



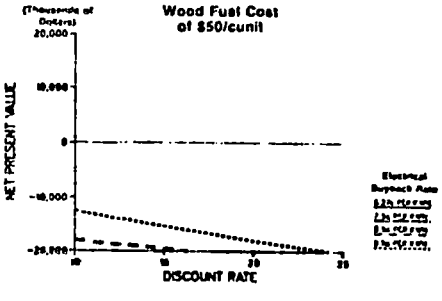

**Base Capital Cost $32.1 Million (1984 Dollars)**



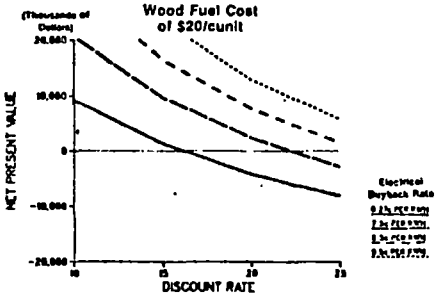

**High Capital Cost $40.1 Million (1984 Dollars)**

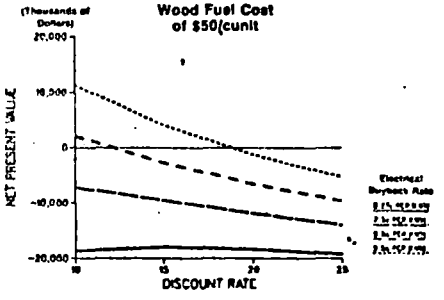


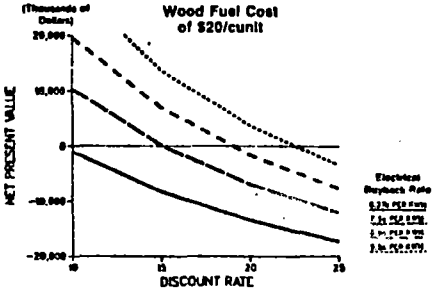
# Figure 5
## Twenty-Five Megawatt Stand Alone Facility (Option 4)
## Net Present Value at Various Discount Rates

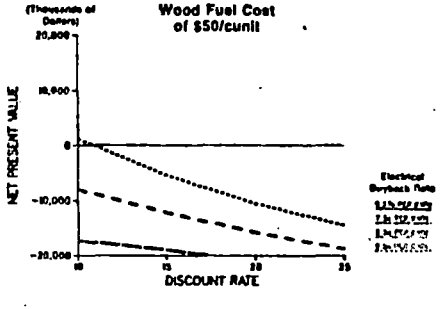
**Low Capital Cost**
**$33.2 Million**
**(1984 Dollars)**



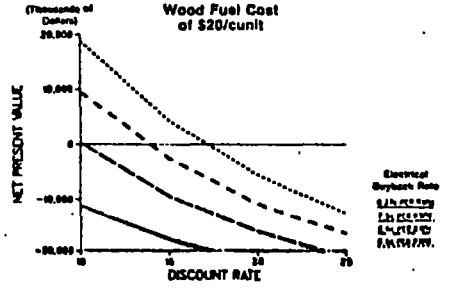



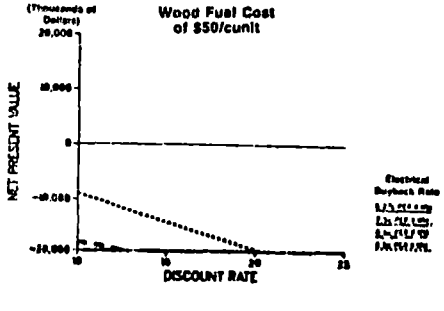

**Base Capital Cost**
**$44.2 Million**
**(1984 Dollars)**




**High Capital Cost**
**$55.2 Million**
**(1984 Dollars)**



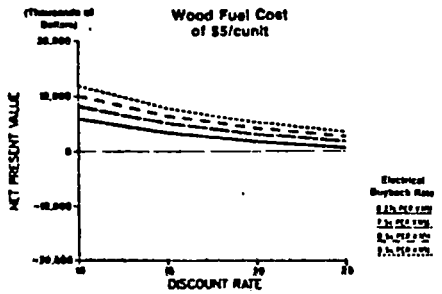
When capital costs are reduced by 25 percent, it is only at the lower wood cost levels ($5 per cunit for the 15-megawatt cogeneration case and $20 for the 25-megawatt stand-alone facility), that the internal rate of return at current fully levelized buyback rates exceeds 14.6 percent.

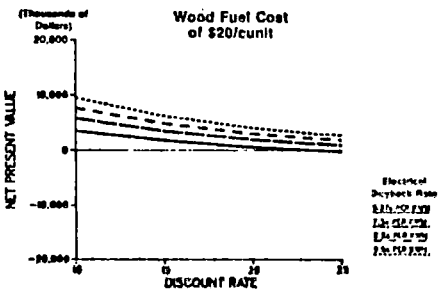
The cost of wood appears to have a substantial impact on the feasibility of wood-fired generating facilities. Reductions in wood cost greatly increase the net present value and internal rate of return.

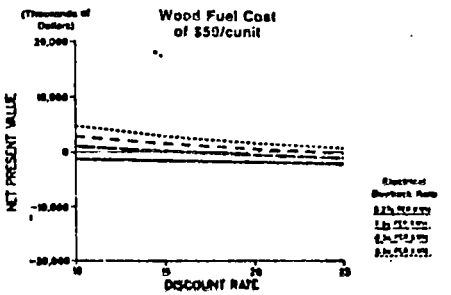
At a $50 per cunit wood cost (representing the cost of forest residue) and current buyback rates, none of the cases offered a positive net present value, even at a 10 percent discount rate. Substantial increases in electrical buyback rates would be required before forest residue would be an appropriate fuel to generate electricity, given new equipment were used.

Reducing capital costs can make the generation of electricity from wood considerably more attractive. Figure 6 indicates the net present value for various discount rates at three levels of wood costs for a cogeneration facility of 5-megawatts with capital costs of $5 million or $1 million per megawatt versus the $1.8 to $2.6 million per megawatt estimated for new equipment. At wood costs of $5 per cunit, a cogeneration facility would offer an attractive investment with an estimated rate of return of over 25 percent, given current buyback rates. At $20 per cunit at current buyback rates, the facility would still offer a rate of return of over 20 percent. Even at much lower capital costs of $1 million per megawatt, forest residue at $50 per cunit does not appear to be feasible.

# Figure 6
# Five Megawatt Cogeneration Facility
# One Million Dollars Per Megawatt Installed Cost
# Net Present Value at Various Discount Rates



## WOOD AS A SUBSTITUTE FUEL FOR NATURAL GAS AND FUEL OIL IN INDUSTRIAL PROCESS BOILERS

The cost per BTU of natural gas or fuel oil indicates that in northwestern Montana relatively high costs could be paid for wood as a substitute fuel. Given the systems had equal capital and operating expenses wood systems could absorb a fuel cost in excess of $80 per cunit and compete with natural gas or number 2 fuel oil (table 6). Capital costs of wood systems are, however, generally considerably higher than those for natural gas or fuel oil.

The feasibility of developing wood systems depends on any reductions in fuel costs relative to these increased capital and operating costs. A financial analysis of two wood-fired process steam systems was done to examine this relationship.

### Variations in Capital Costs

Capital costs of wood systems relative to fuel oil and natural gas systems are subject to tremendous variation. One source indicates new wood systems cost from 2.5 to 7 times as much as the fossil fuel systems (Levi and O'Grady 1980).

In addition, many facilities require boiler systems with a capacity far in excess of their average steam needs throughout the year. Obviously if a system is designed primarily to heat a building the winter load is much greater than the summer load. It is not uncommon for boiler systems to be built at more than twice the average hourly steam need. Variation in utilization of capacity can have a tremendous impact on the financial feasibility of the facility. Because of these sources of variability the financial feasibility of two facilities with different levels of capital costs will be examined for two levels of capacity utilization.

Table 6

Comparison of Energy Available from
Wood and Fossil Fuels on a Cost Basis

| Fuel | Assumed Cost Per Unit | Assumed Combustion Efficiency | Estimated High Heating Value (BTU Per Unit) | Calculated Dollars Per Million BTU |
|---|---|---|---|---|
| Fuel Oil | $ 0.75/gallon | 0.86 | 150,000 | $5.81 |
| Natural Gas | $ 0.0045/cubic foot | 0.79 | 1,035 | $5.50 |
| Wood Fuel | $ 5.00/cunit | 0.65 | 22,500,000 | $0.34 |
| Wood Fuel | $20.00/cunit | 0.65 | 22,500,000 | $1.36 |
| Wood Fuel | $50.00/cunit | 0.65 | 22,500,000 | $3.42 |
| Wood Fuel | $80.00/cunit | 0.65 | 22,500,000 | $5.47 |

Source: Bureau of Business and Economic Research, University of Montana (Missoula, Montana, 1984).

Note: Wood fuel combustion efficiency is based on 50 percent moisture content by weight.

The Model's Assumptions. The evaluation of the financial feasibility of wood as a substitute for natural gas and fuel oil and related assumptions are described below:

- The analysis was based on two boiler systems; one with capacity of 20,000 pounds per hour and one with capacity of 80,000 pounds per hour.
- Operating levels of 80 percent and 40 percent of capacity were examined.
- A fifteen-year useful life was assumed.
- It was assumed that the facility did not have a steam system. The comparison was made between a new wood system and a new fuel oil or natural gas system.
- The costs used in the financial analysis were the excess capital and operating costs of the wood system over the fossil system. The benefits were the reduced fuel costs, if any, per BTU of using wood.
- It was assumed that the firms would use the investment tax credit in the first year and the tax rate on income would be the corporate rate, 46 percent.
- The financial model used was the traditional approach to capital budgeting described by Brigham (1979), and the accelerated cost recovery system method of depreciation is used.
- Capital costs for wood systems were assumed to be 2.5 times a natural gas system and 2.25 times a fuel oil system for the 80,000 pound system. The capital costs of this wood system was $5.8 million with the fuel oil system costing $2.6 million and the natural gas system $2.3 million (General Electric Company

1982, and Schuchart and Associates 1980). Capital costs of the wood system for the 20,000 pound system were approximately 3.4 times the capital costs of the fossil fuel systems. The costs used for the three systems were $2.3 million for the wood, $750 thousand for fuel oil and $667 thousand for natural gas (Lin 1983, and Rafferty 1984).

- Operating costs for the first year were as follows:
  (1) For the 80,000 pound systems: $345 thousand for the wood system and $184 thousand for the fuel oil and natural gas systems.
  (2) For the 20,000 pound systems: $135 thousand for the wood system and $75 thousand for the fuel oil and natural gas systems.

  Operating costs were increased at the rate of 5 percent per year.[6]
- Fuel costs used were $4.50 per thousand cubic feet for natural gas and $.75 per gallon for fuel oil.
- Wood costs ranging up to $75 per cunit were examined.

Financial Feasibility of the Two Systems

Based on these two analyses it is apparent that the feasibility of wood systems in place of natural gas or fuel oil is tremendously variable as is the associated value of wood as a fuel. Examining the larger system (80,000 pounds/hour capacity of process steam) at the

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[6]The growth rate is the forecasted average annual implicit price deflator for the years 1983-2003 by Chase Econometrics in their *U.S. Macroeconomic Long-Term Forecasts*, Third Quarter 1984.

high level of capacity utilization the system would appear feasible even at relatively high wood costs. Figure 7 indicates the rate of return and net present value of an investment in wood systems in place of natural gas or fuel oil for the 80,000 pound per hour system at 80 percent of capacity. Analyses for wood costs of $25, $50, and $75 are indicated.

At $75 per cunit the fuel oil and natural gas systems do not offer rates of return after taxes above 10 percent.

At wood costs of $50 per cunit the substitution of wood for these two fossil fuels would appear to be a very attractive investment given capital costs are no more than 2.5 to 2.25 times those for the natural gas or fuel oil systems.

As expected when capacity utilization of 40 percent is assumed the price a facility could pay for wood and still earn an adequate return is reduced. The rate of return after taxes would be 13 to 15 percent given $50 wood costs (figure 7)[7].

The Smaller System and Increased Capital Costs. As the capital costs of the wood system increase relative to the fossil fuel systems, naturally the financial attractiveness is reduced. The second sized facility evaluated was considerably smaller -- 20,000 pounds per hour capacity. The cost of the smaller system was higher relative to the fossil fuel systems, approximately 3.4 times higher versus 2.25 to 2.5 times as expensive.

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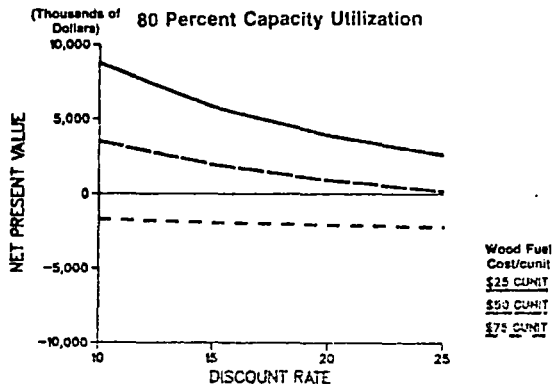
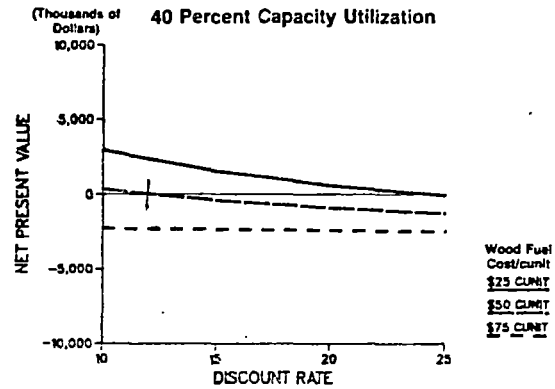
[7]The 80 percent of capacity utilization is typical of many industrial processes with relatively stable year round steam needs. If this steam is used for heat, as is the case for many institutions, the 40 percent utilization level is more typical.

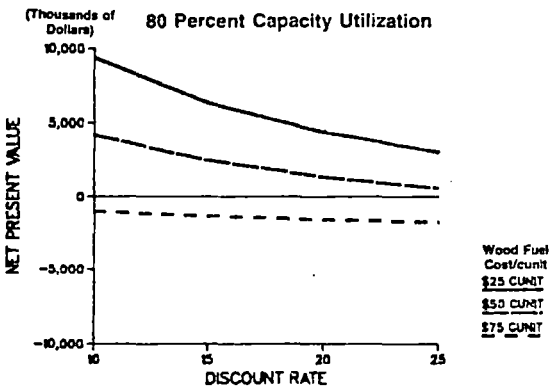
Figure 7

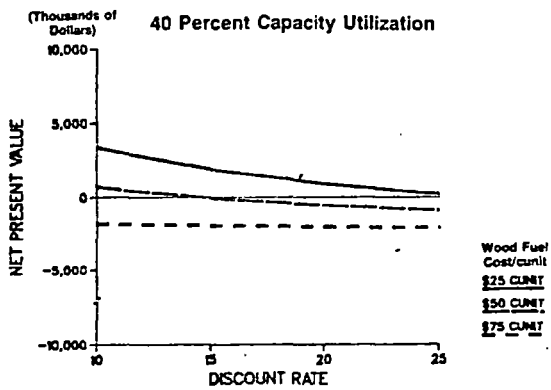
## Net Present Value of Wood Fuel Versus Natural Gas
## 80,000 lb/hr Industrial Boiler Systems




## Net Present Value of Wood Fuel Versus Fuel Oil
## 80,000 lb/hr Industrial Boiler Systems



At an 80 percent utilization of capacity, this wood system did appear to offer an after-tax rate of return of about 15 percent, at wood costs of $50 per cunit (figure 8). When wood costs of $25 per cunit were assumed, the rate of return -- over 25 percent -- certainly made the project feasible as a substitute for both natural gas and fuel oil.

At a capacity utilization level of 40 percent, the smaller wood system appeared to offer an adequate rate of return only at very low wood costs. At $25 per cunit the after-tax return was about 12 percent.

A wood system with capital costs seven times the capital investment for a comparable oil and gas system, as indicated by Levi and O'Grady (1980), would probably not be an attractive investment even if the wood were free.

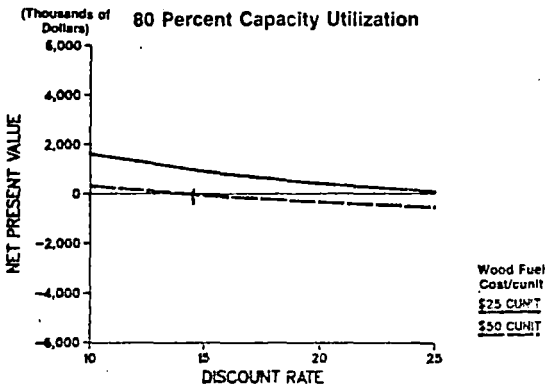
Wood Versus Natural Gas or Fuel Oil

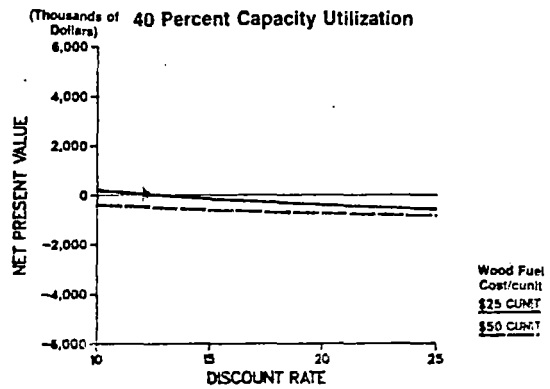
The analysis described above indicates that under certain circumstances the wood systems are more financially attractive than fuel oil or natural gas systems and that they can support relatively high wood costs. In fact, if capital costs of the wood systems are only two to two and one-half times those for the two fossil fuels and the facility will operate at a relatively high rate of capacity utilization, wood costs in excess of $50 per cunit could be borne. This should make forest residue a feasible substitute fuel.

There is tremendous variation in capital costs and capacity utilization. The 80,000 pound system evaluated is larger than that required

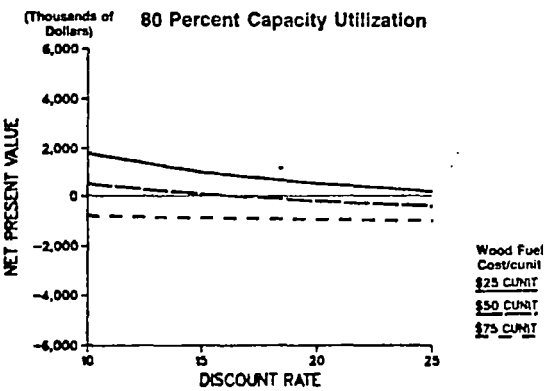
Figure 8

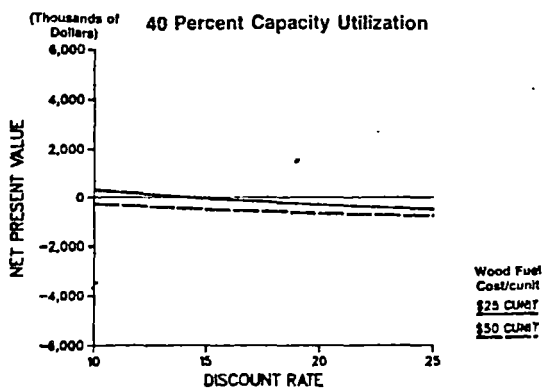
## Net Present Value of Wood Fuel Versus Natural Gas
## 20,000 lb/hr Industrial Boiler Systems




## Net Present Value of Wood Fuel Versus Fuel Oil
## 20,000 lb/hr Industrial Boiler Systems



by most steam users in the area. A 20,000 pound system is more in line with the needs of many of the potential users. These smaller systems can have much higher relative capital costs for wood systems. Seasonal variation in needs greatly reduces capacity utilization for many users. At significantly higher relative capital costs and low capacity utilization, wood systems may not be feasible even if wood were free.

Since many facilities already have fuel oil or natural gas systems, the prospect of replacing the existing system further complicates the overall picture. The choice of a wood system and the value of wood as a fuel in place of fuel oil or natural gas must be handled on a case by case basis. The above analysis does establish, however, that wood can be used in place of these two fossil fuels and it can have a relatively high value (up to $70/cunit) as a fuel replacement, especially for larger systems at a high level of capacity utilization.

## HIGHLIGHTS AND CONCLUSIONS

Two sources of wood fiber residue, mill residue and logging residue, in the Libby area appear to offer potential to supply relatively large volume facilities using wood as a source of energy.

Unutilized mill residue from the manufacture of logs into lumber and plywood is the cheapest potential source. At present slightly more than 100 thousand cunits of unutilized mill residue should be available annually in the area for years of average or above lumber production. Delivered costs for this material are presently relatively low, $10 to $30 per cunit. If a user required the entire 100 thousand plus cunits of unutilized mill residue, the user would, however, probably find it necessary to sharply curtail operations or rely heavily on forest

residue during periods of below average lumber production and mill residue availability. In addition, the unutilized volume represents only a very small percentage of the total supply of mill residue in the Inland Empire region. A relatively small increase in demand or a small decline in total sawmill capacity could immediately eliminate the excess and cause a large increase in price.

Relatively large volumes of logging residue are available annually in the area surrounding Libby, Montana. Based on an inventory of recently logged sties, however, it is apparent that utilization of large cull and dead material is at a high level. Volumes of large relatively sound nonsawtimber wood fiber remaining on sites in the Libby area appear low.

The crowns and unmerchantable bole tips of sawtimber trees offer the most potential to supply a large volume wood residue user. An estimated 120 to 200 thousand cunits should be available annually in the Libby area through logging systems designed to recover top and limb wood from the sawtimber harvest. This material should have an estimated cost delivered and chipped or hogged of approximately $45 per cunit. There should be virtually no competition with product manufacturers for this component of the residue resource.

The generation of electricity from wood in the Libby area appears feasible only given optimum conditions. These would include very low wood costs and capital costs. The use of higher cost forest residue to generate electricity does not appear feasible unless very large increases in electrical buyback rates develop. This looks highly unlikely in the near future.

The use of wood as a substitute fuel for coal would also have a relatively low value and could not be expected to support the costs necessary to recover forest residue.

The analysis indicates that the use of wood as a substitute for fuel oil or natural gas can support relatively high wood costs. Under conditions of low capital costs for wood-fired systems and a high degree of capacity utilization wood costs up to $70 per cunit might be borne. This would mean some components of forest residue would certainly be available. There is tremendous variation in capital cost of wood systems and in the degree of capacity utilization. Systems with high capital costs and/or low capacity utilization might not be feasible even if wood were free.

The Outlook for Wood Residue as an Energy Source. Wood fiber currently is an important source of energy not only in northwestern Montana but throughout the Inland Empire region. In the past twenty years and especially in the last ten years large scale use of wood for energy has developed. In looking to the near term future, one to five years, only limited additional wood energy development should occur in the region. This is because first, electrical buyback rates, which are presently relatively low, will probably be recalculated and lowered due to a surplus of generating capacity throughout the northwest. Second, natural gas and fuel oil prices have declined slightly and may decline further in the next few years.

In looking out further than five years the contribution of wood to the region's energy needs should continue to expand. This should come about primarily through the development of electrical cogeneration projects by wood products manufacturers in the region. The Northwest

Power Planning Council's *Regional Plan* calls for wood-fueled cogeneration systems to supply as much as 400 megawatts of additional electrical power in the northwest in the next twenty years.

Mill residue has been virtually the only source of wood-fueled electrical generation in the Inland Empire and unutilized volumes can support some expansion of cogeneration capacity. However, a significant expansion based on mill residue would either have to be based on a mix of mill and forest residue or it would disrupt the supply of wood fiber to manufacturing plants.

This situation points to two areas in need of further study in the Inland Northwest. These are: 1) a detailed analysis of the potential of the wood products industry to supply additional increments of power and the potential impact of this on other users of wood fiber residue in the region, and 2) the continuing development and evaluation of forest residue recovery systems.

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